Pacific Northwest Forest and Range Experiment Station

Forest Service RESEARCH NOTE

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SHOULD LOG SCALE BE REDUCED FOR KNOTS?

by

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INTRODUCTION

Logs with numerous large knots or limb stubs are commonly subject to a reduction in their net scaled board-foot volumes. This so-called rough cut reduction is made by the scaler to compensate for an expected loss in the quantity, and/or quality, of lumber produced from these knotty or "rough" logs. The validity of this roughness deduction has often been questioned.

The following rough-cut rule is followed by several log scaling and grading bureaus in the Pacific Northwest:[2/] "Any logs so rough that the side cuts will not produce Standard or Better lumber shall have a deduction in scale of a sufficient amount to eliminate the Utility lumber in squaring up the log. This rule is to be applied only to extremely rough logs or especially knotty tops, and does not imply deductions on sound, tight-knotted logs."

With information from four sawmill yield studies, lumber recoveries from rough Douglas-fir logs were compared with recoveries from other Douglas-fir logs to see what differences in yield and value might actually exist. The recovery data were developed during a series of studies conducted in 1964 to 1966 by the Timber Quality Research Project,

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[2/] Puget Sound, Grays Harbor, Southern Oregon, and Northern California Log Scaling and Grading Bureaus. Official log scaling and grading rules. 41 pp. 1966.

Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service, in cooperation with private industry to test and revise coast Douglas-fir log grades. The mills concerned were U.S. Plywood, Mapleton, Oreg.; J. F. Sharp & Co., Yreka, Calif.; U.S. Plywood, Anderson, Calif.; and Timber Products Co., Medford, Oreg.

METHODS USED

A comparison was made of rough and "smooth" logs with respect to their lumber yield and value. All boards sawn from each log were marked by a log identification number. Boards were tallied according to log number, grade, and size so that recovery volume and dollar value of lumber produced could be related to log-scale volume and other log characteristics. Lumber grading was done by Western Wood Products Association or West Coast Lumber Inspection Bureau graders; lumber tallies were made by U.S. Forest Service and other U.S. Government personnel.

Sample Selection

From the scale records for each mill study, a sample of rough and smooth logs was selected. Rough logs were those in each study having no scale deductions except for roughness. The smooth logs, selected for comparison, were only those logs scaled as entirely sound. All logs used for volume recovery comparisons were either No. 2 or No. 3 sawmill grade.[3/] Only No. 3 sawmill logs were used for dollar value comparisons because most rough logs fell in that grade. Log lengths varied from 8 to 26 feet with an average of approximately 16 feet. Diameters ranged from 6 to 42 inches. Table 1 shows a comparison of the number and diameter range of each sample.

Scaling

Scaling followed the National Forest Log Scaling Handbook,[4/] using the Scribner Decimal C scale rule and providing for a diameter reduction for roughness. An experienced Bureau of Land Management scaler scaled all logs. Scaling of rough logs for this investigation was fairly representative of common practice, where variations in determination of roughness are introduced by reliance on human judgment rather than quantitative factors.

[3/] U.S. Forest Service grading rules.

[4/] U.S. Forest Service. National Forest log scaling handbook. FSH 2443.71, 193 pp., illus. 1963.
U.S. Forest Service. National Forest log scaling handbook, R-6 supplement No. 1 to FSH 2443.71 for west side scaling. 45 pp., illus. 1965.

Table 1.--Size of rough and smooth log samples

SIZE OF SAMPLES USED IN VOLUME-RECOVERY DETERMINATIONS

Mill study	Number of logs in sample		Diameter range (inches)	
	Rough	Smooth	Rough	Smooth
Mapleton	28	138	6-30	6-37
Yreka	41	322	8-38	7-42
Anderson	60	421	8-39	7-41
Medford	26	245	7-25	6-42
SIZE OF SAMPLES USED IN DOLLAR-VALUE DETERMINATIONS				
Mapleton	26	58	6-30	6-29
Yreka	28	107	8-38	7-42
Anderson	60	239	8-39	7-36
Medford	26	115	7-25	6-31

The scale used in determining recovery by logs was based on log lengths as sawn on the headrig rather than woods-length logs. The use of the shorter sawmill lengths tends to reduce the variation in recovery in each log-diameter class and provides a better chance for large knots to affect lumber volume under the slab portion of the log because the effects of taper are reduced.

Analysis of Data

Data from each study were treated separately to avoid introducing possible bias attributable to unlike populations.

Volume recoveries by 1-inch diameter classes were computed by dividing lumber tally per log by gross scale and expressing the quotient as percentage. The regression of percent recovery on diameter, expressed as a first- or second-degree polynomial, was fitted by least squares.[5/]

[5/] First-degree curves were used where second-degree curves were not significant.

Dollar values per thousand board feet by 1-inch classes were obtained by dividing log values in dollars by gross scale for each class. These values were also analyzed by fitting first-or second-degree curves to the data and testing differences between fitted curves. The log values are based on average industry lumber prices for 1963.

RESULTS AND DISCUSSION

Volume Recovery

Comparisons between rough and smooth logs for each mill study are shown graphically in figures 1 through 4. In two cases (Mapleton and Yreka), the curves comparing rough with smooth log volume recovery are different in that rough logs below approximately 20 inches in scaling diameter produced higher volumes of sawn lumber than smooth logs of like scaling diameters, whereas above this approximate 20-inch mark, smooth logs produced higher volumes than rough logs.[6/] In the other two cases (Anderson and Medford), no significant difference between rough and smooth log recoveries can be seen for like scaling diameters. However, the tendency for small-diameter logs to show higher volume recoveries for the rough logs is still apparent, although less marked. The rough log recovery curve for the Medford study indicates lower volumes for rough logs over 14 inches in diameter, although the mean volumes for rough and smooth logs are not significantly different. In the Anderson study, rough logs showed higher, but not significantly higher, recoveries for all diameters.

For all four studies, there was a tendency for small rough logs to produce more volume than smooth logs of like diameters. However, where logs of larger diameters were concerned, three of four comparisons showed a tendency for rough logs to produce less volume than smooth logs.

Recovery data for individual logs reveal two factors that seem to govern the differences in volume recovery between rough and smooth logs: log taper and the presence of dead branch stubs larger than 2 and 3 inches in diameter. Live knots, regardless of size, showed no appreciable effect on log volume recovery since most occurred on the smaller rough logs where recoveries were proportionally the highest. Rough logs less than 20 inches in diameter produced more volume than smooth logs of like diameters because of their much greater average taper and correspondingly larger amount of usable wood lying outside their scaled diameters.

[6/] In both cases, the rough vs. smooth curves exhibited significant differences in slope at the 1-percent level of probability.

Figure 1.--*Recoveries for smooth and rough logs by diameters, in percent of gross log scale. Data from Mapleton mill study, 1964.*

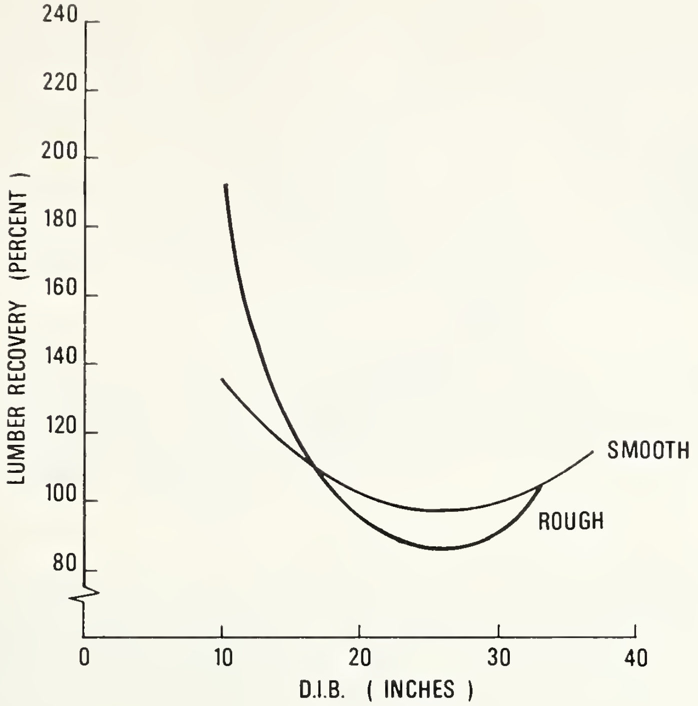


Figure 2.-- *Recoveries for smooth and rough logs by diameters, in percent of gross log scale. Data from Yreka mill study, 1965.*

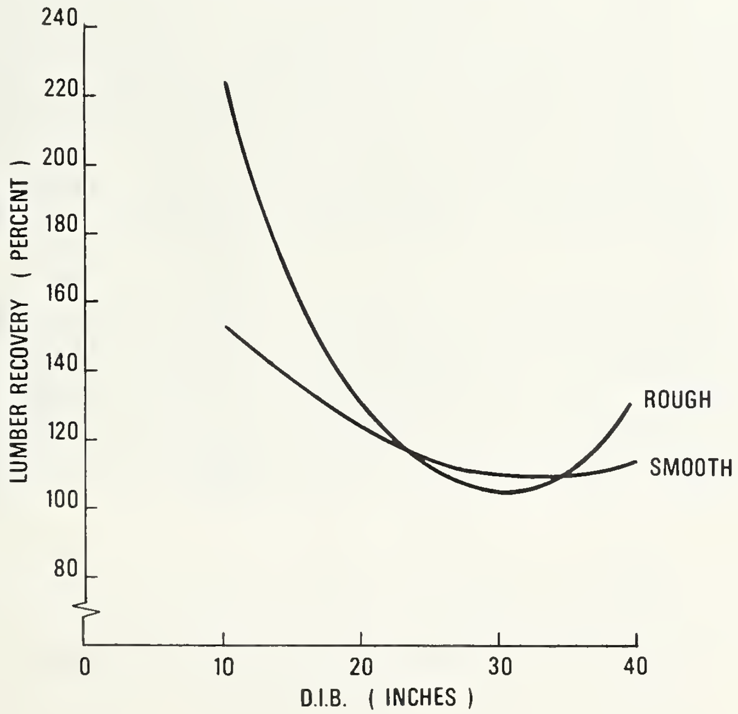


Figure 3.--*Recoveries for smooth and rough logs by diameters, in percent of gross log scale. Data from Anderson mill study, 1965.*

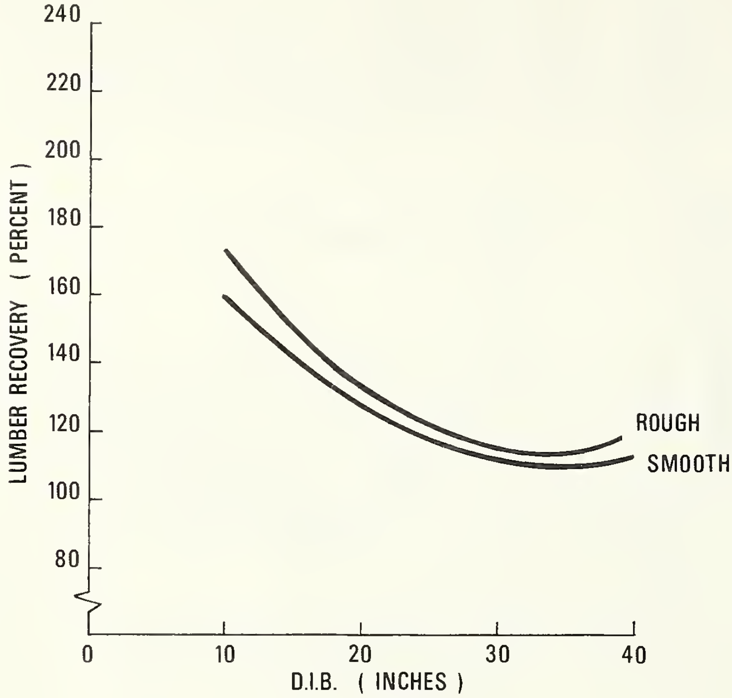
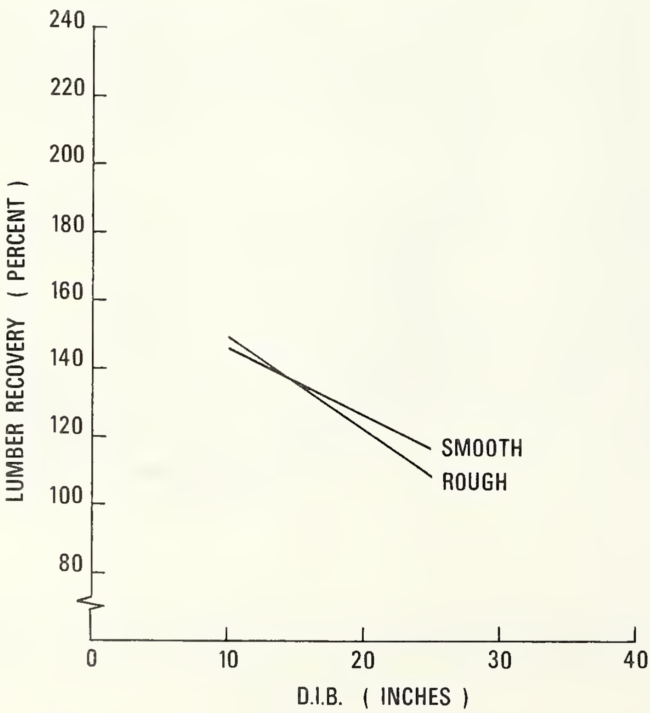


Figure 4.--*Recoveries for smooth and rough logs by diameters, in percent of gross log scale. Data from Medford mill study, 1966.*



For logs over 20 inches in diameter, however, the smaller difference in average taper, coupled with the presence of large dead knots, was reflected in less lumber recovery for rough logs as compared with smooth logs of like diameters. Table 2 shows average taper of rough and smooth logs for each mill study by 5-inch diameter classes. Table 3 shows average number of live and dead knots over 2 and 3 inches in diameter for rough logs by 5-inch log-diameter classes. A comparison of the information in these tables with the curves shown in figures 1 through 4 will confirm these apparent relationships of taper and knot types to recovery.

The average numbers of live and dead knots over 2 and 3 inches are compared for Mapleton study in table 4. It will be noted that there is considerable contrast in surface appearance between the average smooth and rough log. This relationship is typical for all studies.

Log Value

This investigation is concerned with log roughness as a scaling problem. Although log value as related to roughness is primarily a log grading problem, log value comparisons have been included. This was done only because log value in the form of anticipated lumber grade recovery is presently being considered by many scalers in making deductions from gross scaled log volume where rough logs are concerned.

Comparisons of value in dollars per thousand board feet gross scale are shown graphically in figures 5 through 8. In two cases (Mapleton and Yreka), the curves of value by diameter are significantly different between rough and smooth logs and roughly reflect their corresponding volume recovery curves.[7/] Higher lumber values were evident for smaller rough logs compared with smooth logs of like diameters; however, larger rough logs again showed less recovery than smooth logs, this time in dollar value terms. The dollar value curves for the Medford and Anderson studies show lower values for rough logs throughout their lengths. The lower mean dollar values for rough logs in these latter two cases are statistically significant.[8/]

The lower dollar values of rough logs compared with smooth logs over approximately 20 inches in diameter can be reasonably attributed for the most part to the merchantable volume that is apparently lost to large dead knots. It follows, then, that a scale deduction for volume lost to large dead knots will generally compensate for value loss as well. For this reason, no further deduction based on the higher proportion of

[7/] In both cases, the difference in slopes was significant at the 1-percent level of probability.

[8/] For these studies, differences in slope were not significant, but means were significant at the 1-percent level.

Table 2.--Mean taper per 16-foot log, by 5-inch d.i.b. classes, rough and smooth logs--butt logs excluded

Mill study	D.i.b. class	Mean taper		
		Rough	Smooth	Difference
		Inches		
Mapleton	6-10	7.0	1.8	5.2
	11-15	3.8	1.4	2.4
	16-20	2.6	1.3	1.3
	21-25	2.9	1.5	1.4
	26-30	2.0	1.8	.2
	31-35	--	1.0	--
Yreka	6-10	5.2	2.7	2.5
	11-15	4.6	2.2	2.4
	16-20	3.9	2.0	1.9
	21-25	3.4	2.1	1.3
	26-30	3.0	1.8	1.2
	31-35	2.4	2.4	0
Anderson	6-10	5.9	3.0	2.9
	11-15	5.0	2.2	2.8
	16-20	4.9	1.8	3.1
	21-25	3.5	1.9	1.6
	26-30	3.3	1.7	1.6
	31-35	2.2	1.9	.3
Medford	6-10	4.8	2.5	2.3
	11-15	4.9	1.8	3.1
	16-20	4.5	1.9	2.6
	21-25	2.4	1.7	.7
	26-30	--	--	--
	31-35	--	--	--

Table 3.--Average number of live and dead knots > 2 and >3 inches in diameter per rough log, by 5-inch log d.i.b. classes

Mill study	D.i.b. class (inches)	Number of knots > 2 inches			Number of knots > 3 inches			Dead knots[1/]	
		Live	Dead	Total	Live	Dead	Total	> 2 inches	> 3 inches
								------- Percent -------	
Mapleton	6-10	17.7	10.3	28.0	10.0	4.0	14.0	37	29
	11-15	18.2	7.5	25.7	13.5	1.7	15.2	29	11
	16-20	7.3	12.1	19.4	5.0	4.9	9.9	62	49
	21-25	1.6	26.2	27.8	1.6	17.0	18.6	94	91
	26-30	1.3	18.8	20.1	1.3	9.8	11.1	94	88
	31-35	--	--	--	--	--	--	--	--
Yreka	6-10	30.5	1.0	31.5	27.5	.5	28.0	3	2
	11-15	21.6	11.0	32.6	18.3	4.9	23.2	34	21
	16-20	18.1	9.8	27.9	17.2	5.3	22.5	35	24
	21-25	13.7	10.9	24.6	12.8	6.4	19.2	44	33
	26-30	11.2	14.5	25.7	10.6	11.2	21.8	56	51
	31-35	6.3	11.3	17.6	6.0	8.3	14.3	64	58
Anderson	6-10	22.1	5.7	27.8	19.4	2.0	21.4	21	9
	11-15	20.1	9.7	29.8	20.1	6.1	26.2	33	23
	16-20	22.1	13.6	35.7	22.1	9.4	31.5	38	30
	21-25	14.6	17.1	31.7	14.6	11.3	25.9	54	44
	26-30	9.7	15.0	24.7	9.7	10.9	19.6	61	56
	31-35	5.8	21.5	27.3	5.8	16.0	21.8	79	73
Medford	6-10	28.0	1.0	29.0	23.0	.2	23.2	3	1
	11-15	20.0	8.0	28.0	18.5	5.6	24.1	29	23
	16-20	15.1	17.0	32.1	13.8	9.8	23.6	53	42
	21-25	12.8	16.8	29.6	12.8	10.8	23.6	57	46
	26-30	--	--	--	--	--	--	--	--
	31-35	--	--	--	--	--	--	--	--

1/ Number of dead knots expressed as a percentage of total number of knots in each size class.

Table 4.--Average number of live and dead knots >2 and >3 inches in diameter per 16 feet of log length for rough and smooth logs from the Mapleton study

Scaling diameter class (inches)	Rough logs					Smooth logs				
	Live knots		Dead knots		Total	Live knots		Dead knots		Total
	> 2	> 3	> 2	> 3	> 2	> 2	> 3	> 2	> 3	> 2
6-10	17.7	10.0	10.3	4.0	28.0	2.4	0.7	1.2	0.4	3.6
11-15	18.2	13.5	7.5	1.7	25.7	2.2	.7	1.5	.1	3.7
16-20	7.3	5.0	12.1	4.9	19.4	1.4	.4	2.2	.4	3.6
21-25	1.6	1.6	26.2	17.0	27.8	.8	.4	3.4	.5	4.2
26-30	1.3	1.3	18.8	9.8	20.2	1.4	.9	4.6	1.4	6.0

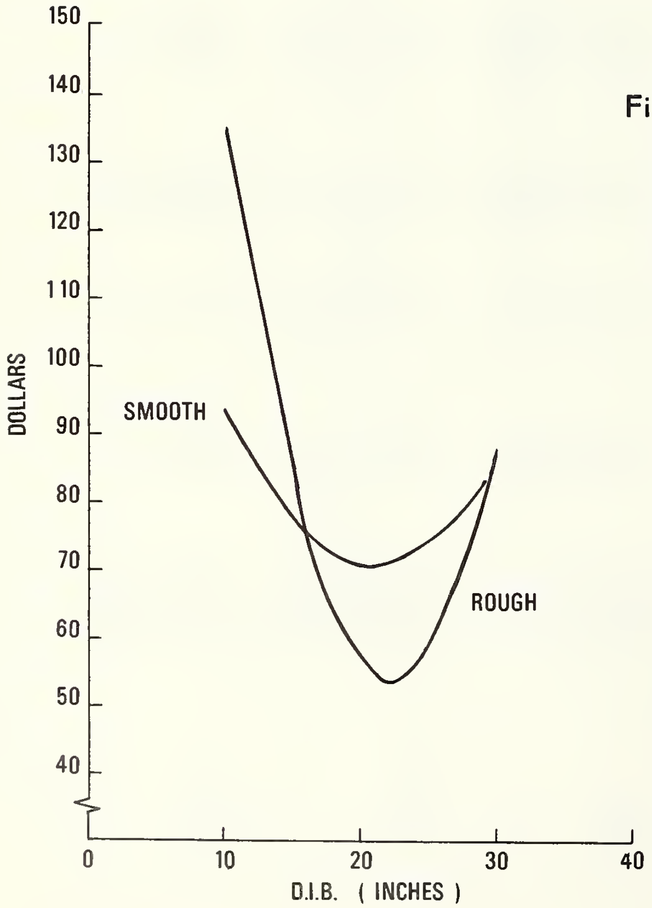


Figure 5.--*Values of smooth and rough logs by diameters, in dollars per thousand board feet gross log scale. Data from Mapleton mill study, 1964.*

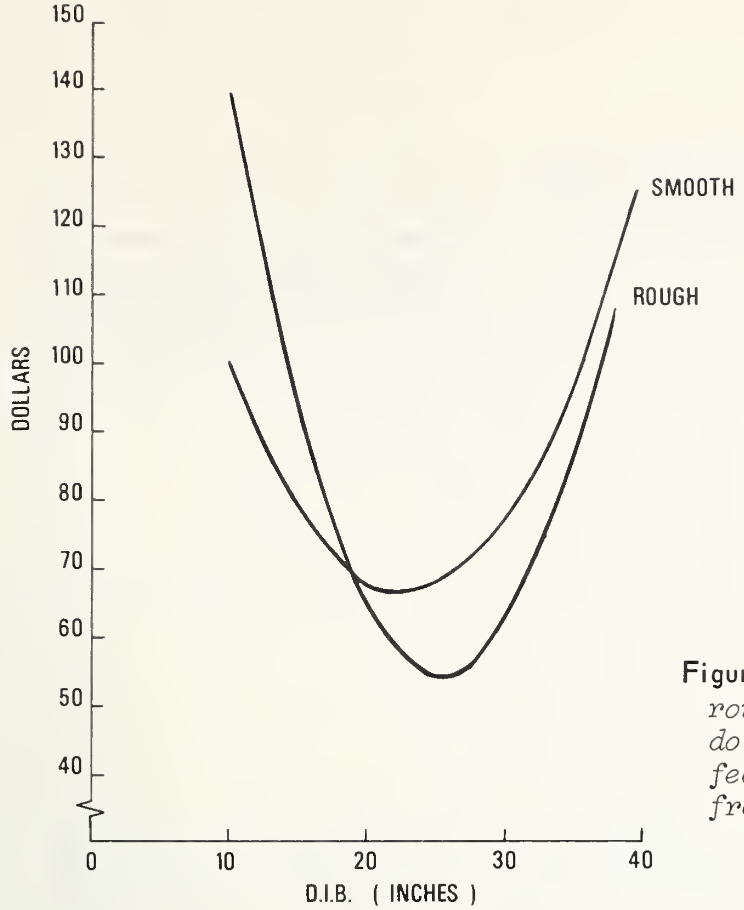


Figure 6.--*Values of smooth and rough logs by diameters, in dollars per thousand board feet gross log scale. Data from Yreka mill study, 1965.*

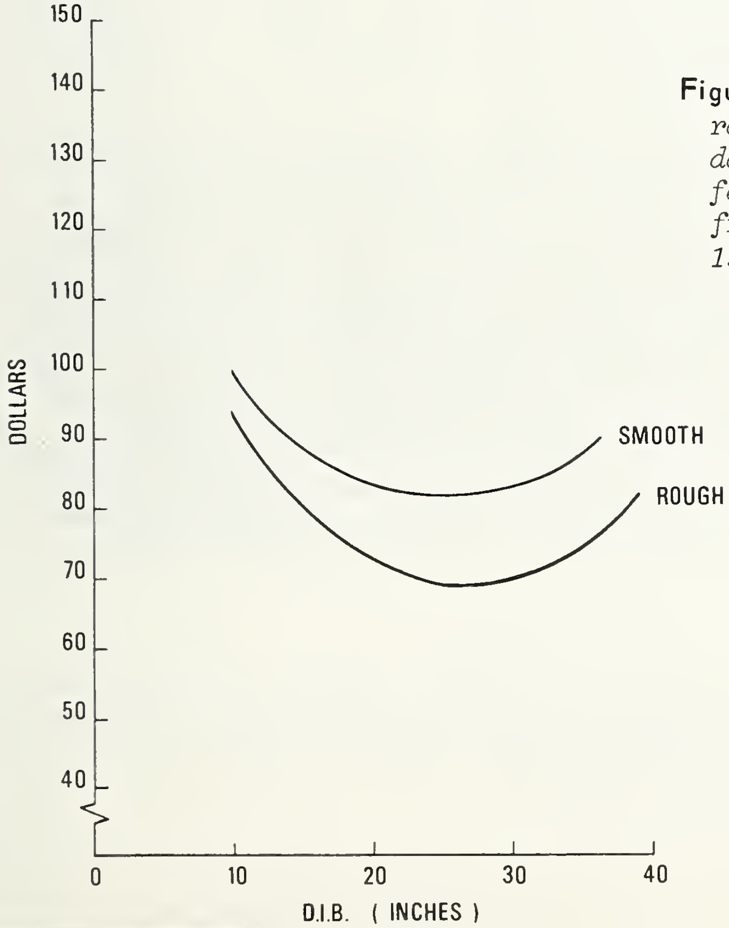


Figure 7.--*Values of smooth and rough logs by diameters, in dollars per thousand board feet gross log scale. Data from Anderson mill study, 1965.*

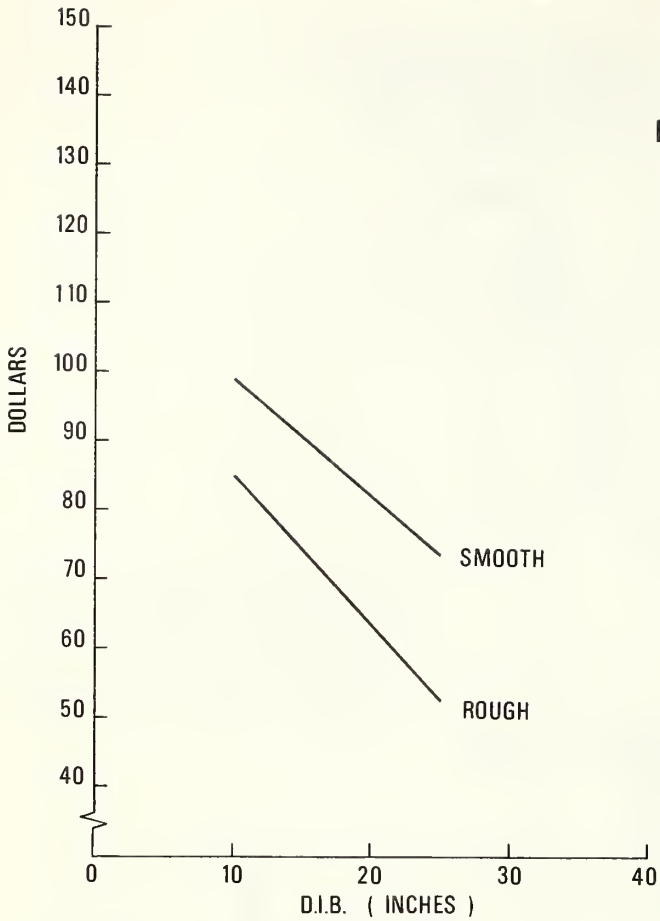


Figure 8.--*Values of smooth and rough logs by diameters, in dollars per thousand board feet gross log scale. Data from Medford mill study, 1966.*

low-grade lumber in rough logs is justified. Where logs less than 20 inches in diameter were concerned, no firm basis for deductions for roughness existed. The fact that in two cases these rough logs had less average dollar value than smooth logs of the same grade is countered by the fact that in two cases the reverse was also true. Also, as scaling is generally restricted to determining log volume, the problems of assigning value to logs based on end-product yield should be left to log grading. It is likely that a grading system could be developed that would more effectively reconcile log value discrepancies that arise between logs of the same diameter and present grades.

Further Considerations

It was noted that the maximum average difference between volume recoveries, where rough logs showed less recovery than smooth logs in any study, was approximately 15 percent (Mapleton study, figure 1).

This corresponds roughly to a 2-inch deduction where 25-inch logs are concerned. This leads to the recommendation that rough deductions generally should not exceed 2 inches of scaling diameter and that a 1-inch deduction is often more than sufficient, depending on log taper and size of deductible knots.

The determination of what comprises a rough log remains difficult. The samples used in this investigation may provide a rough guide. It appeared that logs showing a sawn volume loss attributable to roughness and warranting a scale deduction had an average of 12 to 15 or more dead knots 2 inches in diameter or larger, of which half or more were 3 inches in diameter or larger, with a rising proportion of knots over 3 inches as log diameters increased. This is hardly the basis for an ironclad rule, as taper and other factors would have to be considered. As a definition, it remains untested, being based only on the data collected for this investigation.

CONCLUSIONS

1. A loss in merchantable log volume may occur when 2-inch and larger dead branch stubs indicate there will be loose knots deeper than 2 or 3 inches from the surface of the log.

2. Large live branch stubs indicate tight knots which have no detectable effect on the merchantable volume that can be recovered in sawing.

3. Log taper is an extremely important consideration where roughness deductions are concerned. Rough logs nearly always have more taper than smooth logs. The effect of taper often compensates for the effect of large loose knots on merchantable log volume.

4. No strict rule regarding the identification of logs warranting a scale deduction for roughness is furnished by this investigation. The data suggest the following as a guide: Logs requiring a roughness deduction are those having 12 or more large (2 or more inches in diameter) dead knots per 16 feet of length, with at least half the total number consisting of 3-inch knots or larger for logs less than 20 inches in diameter or three-quarters of the total consisting of 3-inch knots or larger for logs above 20 inches in diameter.

RECOMMENDATIONS

1. Make volume deduction for log roughness only when dead branch stubs indicate that there will be loose knots deeper than 2 or 3 inches from the surface of the log.

2. Consider taper in every case of apparent roughness to prevent unwarranted deductions for superficial loose knots. Taper not only keeps some superficial dead knots out of cants near the large ends of logs but may also increase the size of the usable cant near the large end.

3. Delete references in present scaling rules to especially knotty top logs as a particular case of roughness requiring a deduction. Such logs generally have the fewest large dead knots and the highest rates of taper. Also, since most top logs have more live limbs than dead, this rule may lead to unwarranted scale deduction if the scaler observes the abundance rather than the soundness of the knots.

4. Scale deductions for large dead knots should not generally exceed the equivalent of 1 or 2 inches of scaling diameter. Limit 2-inch diameter deductions to the more extreme cases of dead knot size and number.

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